

## 17.

Caudal Skeleton of Bermuda Shallow Water Fishes. II. Order  
Percomorphi, Suborder Percosoces: Atherinidae,  
Mugilidae, Sphyraenidae<sup>1</sup>.

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(Text-figures 1 to 14).

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INTRODUCTION.

This is the second of a series of papers dealing with the caudal skeleton of Bermuda fishes.<sup>2</sup> This paper deals principally with the adult fishes, as does Part I on the Bermuda Isospondyli, but when young stages were available these were included.

In Atherinidae, *Menidia notata* is known from Bermuda by a single record, (Barbour, *Bull. Mus. Comp. Zool.*, vol. XLVI, No. 7, page 116, 1905). The single specimen upon which it is based could not be found. This record is questionable and it is possible that *Menidia* does not exist in Bermuda. The account of *Menidia menidia* has already been shown to be *Atherina harringtonensis*. (Beebe and Tee-Van, *Zoologica*, XIII, 7, 1933, page 143). *Menidia* has not been taken by us and as *Atherina* is common, *Menidia notata* is not included in this study, on the assumption that the single record is the same as *Atherina harringtonensis*.

<sup>1</sup> Contribution No. 532, Department of Tropical Research, New York Zoological Society.

Contribution from the Bermuda Biological Station for Research, Inc.

<sup>2</sup> Caudal Skeleton of Bermuda Shallow Water Fishes. I. Order Isospondyli: Elopidae, Megalopidae, Albulidae, Clupeidae, Dussumieriidae, Engraulidae. *Zoologica*, New York Zoological Society, Vol. XXI, Dec. 31, 1936.

KEY TO CAUDAL FIN OF BERMUDA SHALLOW WATER PERCESOID FISHES.

(Text-figs. 1-3).

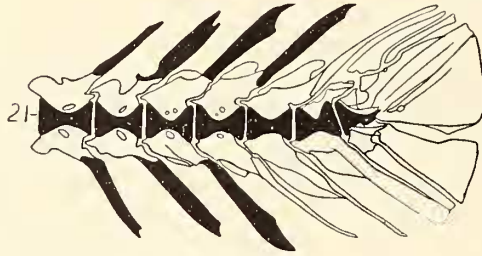
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Group I

Brood posterior neural  
and haemol spines;  
21 caudal vertebrae;  
43 total vertebrae;  
2 epurals, rarely 1.

ATHERINIDAE

*Atherina harringtonensis*



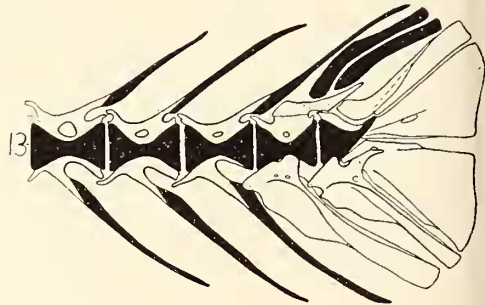
Text-figure 1.

Sub-Group A

2 epurals;  
epural bases anterior to neu-  
ral of lost centrum;  
neural of lost centrum sharply  
pointed;  
13 caudal vertebrae;  
Post. haemol processes arise  
on anterior half of centro.

MUGILIDAE

*Mugil curema*  
*Mugil trichodon*  
*Mugil brasiliensis*



Text-figure 2.

Group II

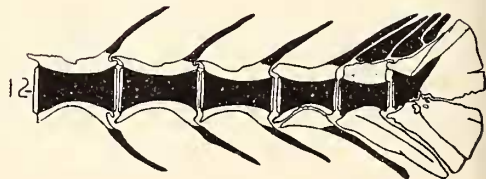
Slender posterior neural and  
haemol spines;  
12 or 13 caudal vertebrae;  
24 total vertebrae;  
2 or 3 epurals.

Sub-Group B

3 epurals;  
epural bases not anterior to  
neural of lost centrum;  
neural of lost centrum not  
pointed;  
12 caudal vertebrae.  
Post. haemol processes arise  
on post. half of centra.

SPHYRAENIDAE

*Sphyraena barracuda*  
*Sphyraena borealis*



Text-figure 3.

In Mugilidae, *Mugil curema* is the common species. *Mugil trichodon* and *Mugil brasiliensis* are the uncommon species. The latter has not been taken during our seven seasons of work in Bermuda. Three specimens were presented for this study by the United States National Museum.

In Sphyraenidae, *Sphyraena sphyraena* is omitted, being a questionable species in Bermuda. In the "Field Book of the Shore Fishes of Bermuda," Beebe and Tee-Van, it "has twice been recorded from Bermuda. Both records are questionable and it is possible that the fish does not occur here at all." Because of almost identical characters of the osteology of the tail, *S. borealis* and *S. picudilla* are in this paper considered as one, and the name *Sphyraena borealis*, is used for both.

The length of specimens in this paper is standard length unless otherwise stated.

For caudal fin terminology, complete bibliography, and method of preparing specimens for this study, refer to Part I.

The symbols used in the figures are UN, uroneurals; EP, epurals; 1, 2, 3 etc., hypurals.

We are indebted to the American Museum of Natural History for specimens of *Menidia notata* and to the U. S. National Museum for three specimens of *Mugil brasiliensis*. I take this opportunity to thank Dr. William Beebe, Director of this Department, for his continued encouragement, and Mr. John Tee-Van for his cooperation. The drawings are by Mr. George Swanson and the author.

In the key a single figure is used to represent the three species of Mugilidae and another for the two species of Sphyraenidae. In both families the drawings are of the largest adults of the common species, *Mugil curema* and *Sphyraena barracuda*. The slight differences found in the caudal pattern of the other species are described in the text.

#### ATHERINIDAE.

### *Atherina harringtonensis* Goode.

(Text-figs. 4-7).

#### Diagnostic Characters:

- 4 hypurals, 2 dorsal and 2 ventral in 64 mm. fishes.
- 5 hypurals, 3 dorsal and 2 ventral in 28 mm. and smaller fishes.
- Several broad posterior neural and haemal spines.
- 2 epurals in all specimens but one of 64 mm.
- Vertebral count: 21 caudal plus 22 trunk. Total 43.

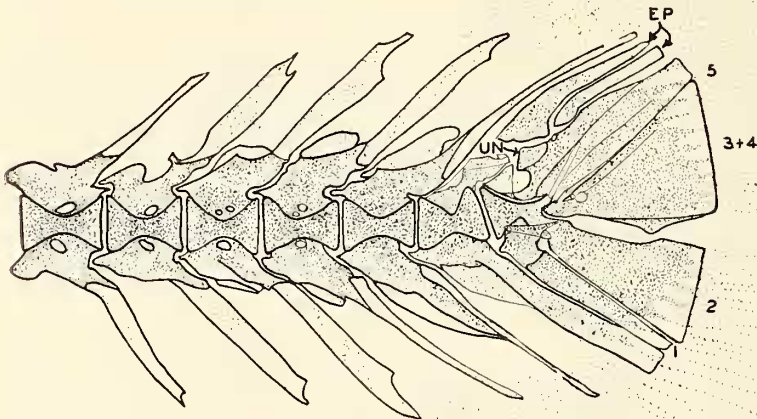
#### Material Studied.

Length.	KOH Cat. No.	Text-fig. No.	Ossification.
64 mm.	654	4	Complete.
60 mm.	855		"
55 mm.	654		"
52 mm.	654		"
50 mm.	205		"
50 mm.	656		"
47 mm.	206		"
47 mm.	1072		"
45 mm.	654		"
38 mm.	654		"
37 mm.	205		"
35 mm.	206		"
35 mm.	654 (2 spec.).		"

Length.	KOH Cat. No.	Text-fig. No.	Ossification.
28 mm.	654 (2 spec.).	5	Complete.
13 mm.	2106 (2 spec.).	6	Partial.
9 mm.	2106		Slight,
			vertebral column segmented.
6 mm.	2106 (2 spec.).	7	None,
			vert. column unsegmented.
5 mm.	2106	7	None.

#### Caudal Osteology.

*Urostyle*: Separate segments of the urostyle cannot be found in any of the specimens examined which range in size from 5 mm. to 64 mm. In the 64 mm. fishes the urostyle is very much reduced, its blunt posterior end appearing above the base of the dorsal fan-like hypural. In the 28 mm. specimen it is near the base of the 4th hypural. In the 13 mm. fish, which is not completely ossified, it is even more elongated and the tip is rounder and lies above the base of the 5th hypural. In the 5 mm. fish, which has no evidence of ossification, the vertebral segments are not developed and the urostyle extends dorsally beyond the distal margin of the 5th or dorsalmost hypural.

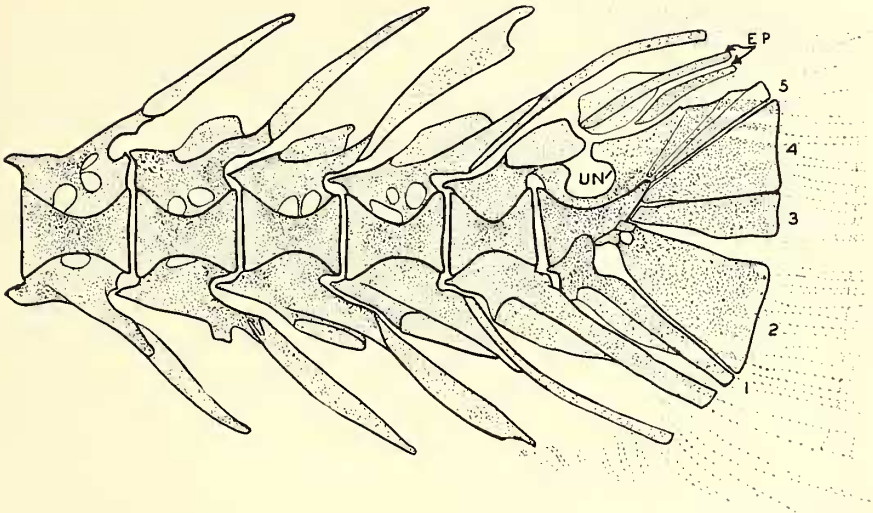


Text-figure 4.

*Atherina harringtonensis*. Tail of 64 mm. specimen with 3d and 4th hypurals fused and 5th hypural consolidated with the uroneural. (x 11.9).

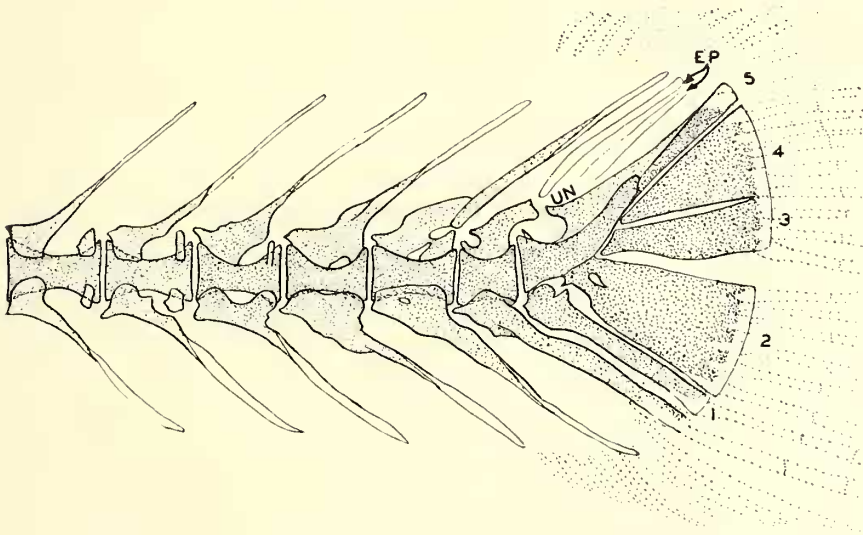
*Uroneurals*: In the 13 mm. specimen one pair of uroneurals is present which covers all but the anterior margin of the dorsal surface of the urostyle which is covered by the diminutive zygapophysis. In the two larger stages the uroneurals are enlarged and have become one with the base of the zygapophysis, and the depth has increased so that the area between the urostyle and the epurals is almost completely filled. In the 13 mm. fish the distal end of the uroneurals is closely connected with the dorsal surface of the dorsalmost hypural. In the larger specimens the line of junction between the two is faint and the identity of the two bones is further complicated by additional lines. But from the structure of the 13 mm. specimen it is thought that the adult has but one pair of uroneurals.





Text-figure 5.

*Atherina harringtonensis*. Tail of 28 mm. specimen with the five hypurals defined but the dorsal surface of the 5th united with the uroneural. (x 29.8).

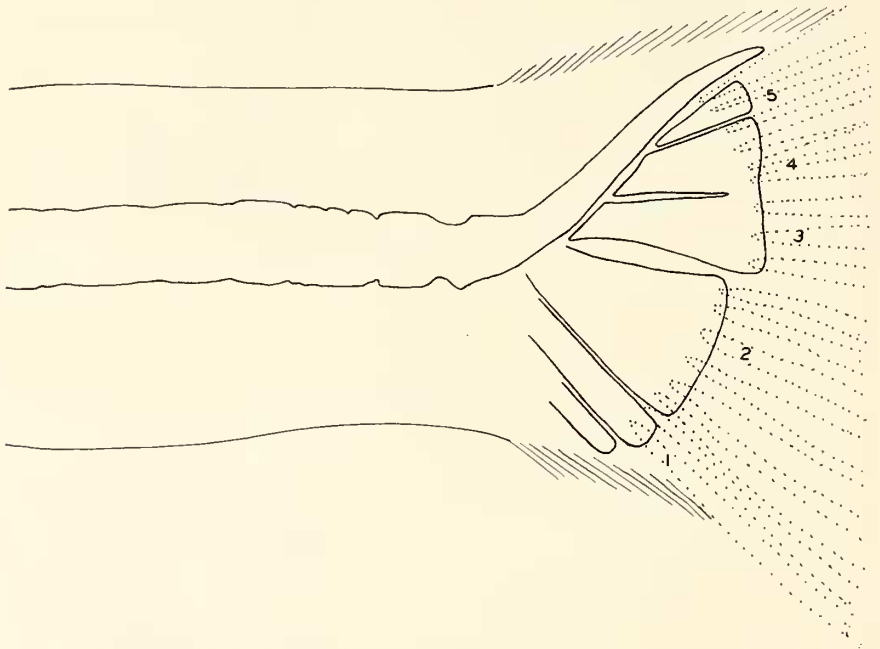


Text-figure 6.

*Atherina harringtonensis*. Tail of 13 mm. specimen with the unossified areas not stippled. (x 45.6).

*Hypurals*: There are four hypurals, two below and two above the median line, in the largest or 64 mm. specimens. In the 28 mm. and smaller fishes there are five hypurals, two below and three above the median line. In

all specimens there remains evidence of a one-time division of the second hypural which is indicated by a small hole near the base. In the 28 mm. fish the heavy spine of the 1st hypural has been omitted in the illustration in order to show the base of the 2nd hypural with the hole and the double nature of the arch portion. (Text-fig. 5). In all of the Bermuda *Isospondyli* there are three hypurals below the median line, instead of two found in the Bermuda *Percesoces*.



Text-figure 7.

*Atherina harringtonensis*. Tail of 5 mm. specimen which is unossified. The column is unsegmented into vertebrae. (x 93.2).

In the 64 mm. *Atherina* the 3rd and 4th hypurals have united to form a large fan-shaped bone similar to the one below the median line. The complete outline of the 5th hypural is difficult to trace in specimens over 28 mm. in length when it becomes united dorsally with the uroneurals. In the younger stages it is clearly defined both in position and outline.

*Epurals*: There are two epurals in all specimens examined except one 64 mm. long. In the 13 mm. fish the epurals are not ossified and their outline can only faintly and incompletely be traced. In all larger specimens the epurals are long flat bones and the anterior one is always longer and broader, having a larger area to fill.

*Specialized Neural Processes*: The spine of the neural process on the terminal posterior centrum is greatly reduced, with a blunt distal portion which, in the large specimens, overlaps the zygapophysis of the urostyle and extends almost to the base of the anterior epural. The neural arches, as well as the haemal arches, have complicated superstructures which do not appear in the two other families of this suborder.

*Caudal Fin Ray Count:*

64 mm.	$\frac{9 + 10 = 19}{9 + 9 = 18}$	(Text-fig. 4).
28 mm.	$\frac{9 + 8 = 17}{9 + 8 = 17}$	(Text-fig. 5).
13 mm.	$\frac{10 + 9 = 19}{9 + 8 = 17}$	(Text-fig. 6).
9 mm.	$\frac{17}{16}$	
5 mm.	$\frac{9}{8}$	(Text-fig. 7).

## MUGILIDAE.

1. *Mugil curema* Cuvier and Valenciennes.*Diagnostic Characters:*

4 hypurals, 2 dorsal and 2 ventral in 10 mm. and larger fishes.

6 hypurals indicated in the unossified 6 mm. specimen.

Narrow posterior neural and haemal spines.

2 epurals whose bases are anterior to the tip of the neural of the last centrum.

Neural spine of the last centrum sharply pointed.

Haemal processes arising on the anterior half of the caudal centra.

Vertebral count: 13 caudal plus 11 trunk. Total 24.

*Material Studied.*

Specimens ranging in size from 4 mm. to 23 mm., taken in Haiti, were used for additional study but not tabulated below. One is included in this study which is a stage not found in our Bermuda material.

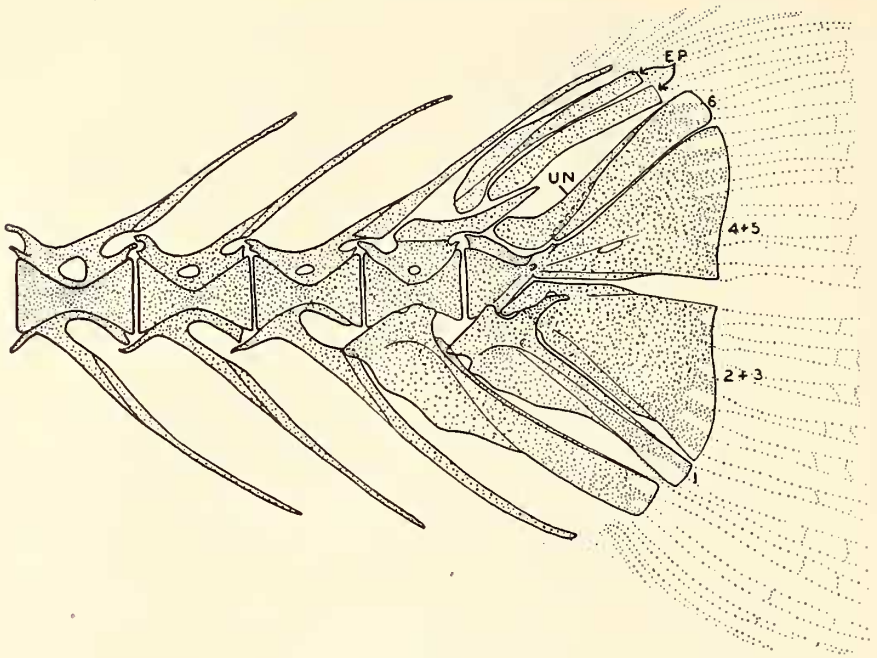
<i>Length.</i>	<i>Cat. No.</i>	<i>KOH Cat. No.</i>	<i>Text-fig. No.</i>	<i>Ossification.</i>
202 mm.	9474	979		Complete.
149 mm.	25041	1045		"
70 mm.	25042	1044	8	"
49 mm.		593		"
32 mm.		593		"
32 mm.		503		"
30 mm.		503		"
30 mm.		2094		"
28 mm.		2094		"
25 mm.		2094		"
12 mm.*	16465	594	9	Partial.
10 mm.	7306 (Haiti).	2093	10	Partial, column segmented.
6 mm.†	19757b	2107	11	Slight, column unsegmented.

\*Dip. net 5 miles off shore.

†Surface net 3 miles off Gurnets.

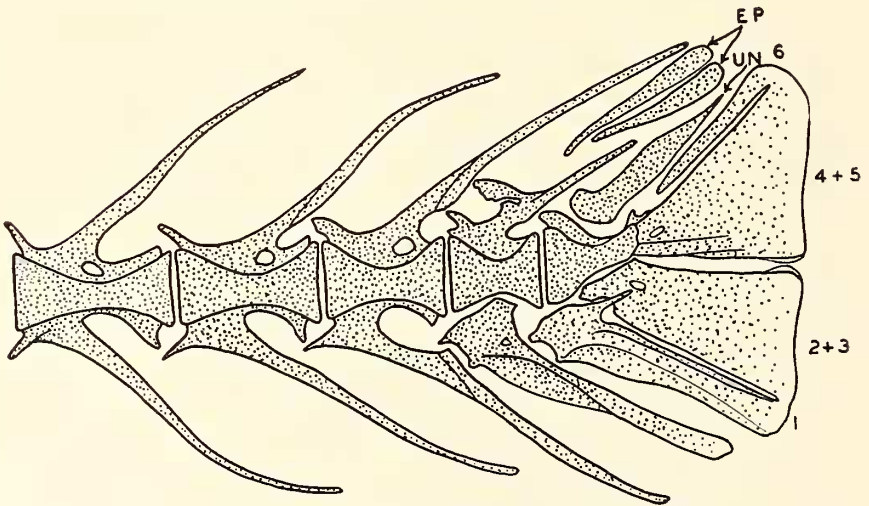
*Caudal Osteology.*

*Urostyle:* The urostyle segment looks like a perfect half centrum. No separate elements can be seen in the reduced urostyle of specimens which range in length from 202 mm. to 12 mm. In a 10 mm. fish the upturned urostyle is more prolonged than in the 12 mm. specimen and extends to the



Text-figure 8.

*Mugil curema*. Tail of 70 mm. specimen which represents all larger stages in our collection. (x 8.7).

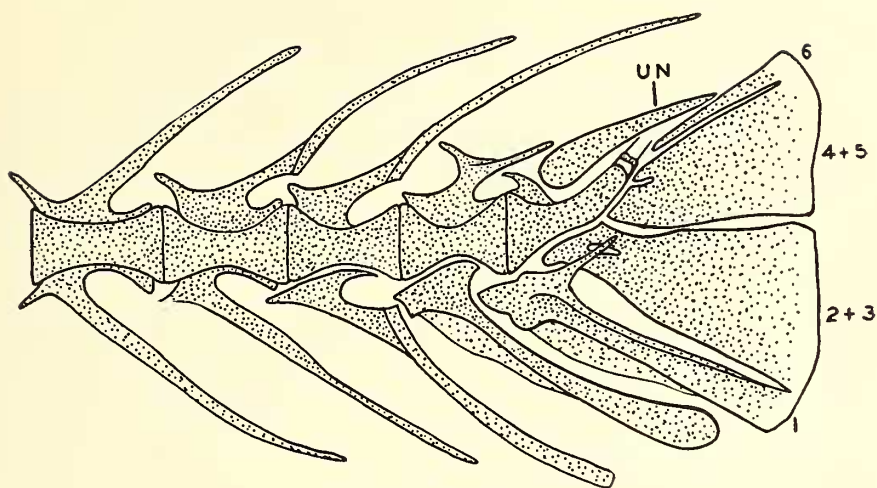


Text-figure 9.

*Mugil curema*. Tail of 12 mm. specimen showing remnants of the urostyle, immature epurals and uroneurals and partially ossified skeleton. (x 43.2).

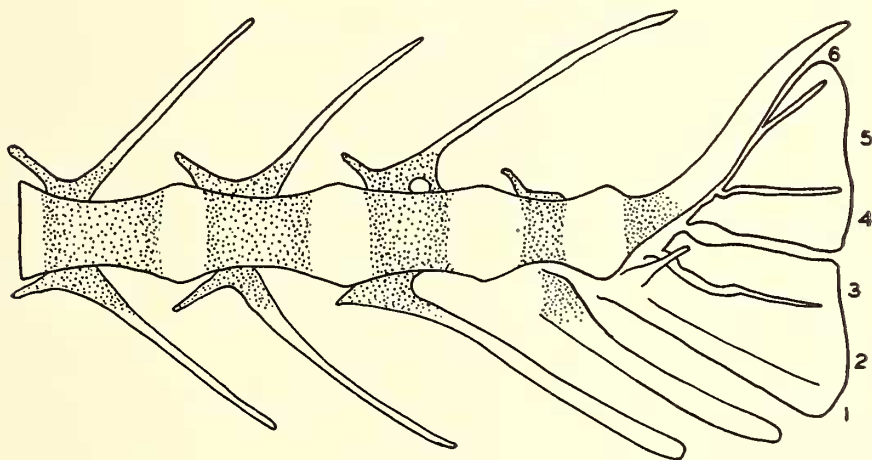
dorsal margin of the base of the upper fan-shaped hypural. Extending beyond is the remnant of the unossified notochord. The 6 mm. specimen, which has only slight ossification in the center of the developing centra and





Text-figure 10.

*Mugil curema*. Tail of 10 mm. specimen only partially ossified, hypural bases free from upturned urostyle, margins of centra in conjunction, no epurals and skeleton only partially ossified. (x 53.7).



Text-figure 11.

*Mugil curema*. Tail of 6 mm. specimen which is only slightly ossified and the vertebral column as yet unsegmented. The urostyle is prolonged beyond the margin of the hypurals. The bases of six hypurals are distinct. (x 73.2).

the neural and haemal arches, has a prolonged notochord which curves dorsally beyond the margin of the dorsalmost hypural.

*Uroneurals*: There is one pair of uroneurals, the two bones of which are club-shaped ventrally and taper dorsally to a slender tip. In the 70 mm. specimen they extend almost to the dorsal margin of the 4th hypural. In this and larger specimens the ventral half of the uroneurals overlaps the side of the 4th hypural. In smaller specimens there is definite space between the two bones. In 12 mm. and 10 mm. fishes the dorsal tip reaches half and

a little more than half the length of their respective hypurals. In the slightly ossified 6 mm. specimen there is no evidence of the uroneurals.

*Hypurals*: There are four hypurals, two below and two above the median line in all specimens of 10 mm. and larger. There is indication of six hypurals in the 6 mm. specimen, none of which is ossified. Here the bases are deeply cleft but these do not extend through the distal margin to divide the bone into two hypurals. With growth the clefts gradually disappear and only a small hole remains at the base. This condition is also seen in *Atherina*. As in *Atherina* and *Sphyraena* there are two large fan-shaped hypurals, one dorsal and one ventral to the median line.

*Epurals*: Two epurals are present in all specimens ranging from 12 mm. to the largest. Both are long, flat bones which are slightly larger at the ventral end. The epurals are first seen in the 12 mm. fish and here the ventral ends are more slender than the dorsal. But with growth the ventral ends become larger. The bases of both epurals are anterior to the posterior tip of the last neural spine.

*Specialized Neural Processes*: The spine of the neural process on the terminal posterior centrum is reduced but more spine-like than in Atherinidae and Sphyraenidae. It differs from the neural process of both families in being long and slender and its pointed distal tip extending posteriorly and dorsally beyond the ventral bases of both epurals. The illustrations show the progressive growth of this bone.

*Caudal Fin Ray Count*:

149 mm.	$\begin{array}{r} 5 + 10 = 15 \\ 6 + 10 = 16 \end{array}$	
70 mm.	$\begin{array}{r} 5 + 10 = 15 \\ 6 + 10 = 16 \end{array}$	(Text-fig. 8).
49 mm.	$\begin{array}{r} 4 + 10 = 14 \\ 6 + 9 = 15 \end{array}$	
32 mm.	$\begin{array}{r} 6 + 8 = 14 \\ 7 + 8 = 15 \end{array}$	
25 mm.	$\begin{array}{r} 7 + 8 = 15 \\ 8 + 8 = 16 \end{array}$	
6 mm.	$\begin{array}{r} 13 \\ 13 \end{array}$	

*Additional Characters Worthy of Note*: The bases of the posterior caudal haemal arches arise anterior to the center of their centra and, on the posterior half of the centra, form a deep-cut U. This pattern is distinctive and does not exist in Atherinidae or Sphyraenidae. In the latter the haemal arches arise posterior, instead of anterior, to the center of the centra.

## 2. *Mugil trichodon* Poey.

### 3. *Mugil brasiliensis* Agassiz.

The caudal patterns of *Mugil trichodon* and *Mugil brasiliensis* are almost identical and are not noticeably different from *Mugil curema*. The vertebral count is the same in the three species; 13 caudal plus 11 trunk. Total 24.

In *Mugil trichodon* the scales are larger and the body more slender and the skeleton more slender and the reverse is true in *Mugil brasiliensis*.

## MUGIL TRICHODON.

*Material Studied.*

<i>Length.</i>	<i>KOH Cat. No.</i>	<i>Cat. No.</i>	<i>Caudal Fin Ray Count.</i>
165 mm.	2167		$\frac{4 + 10 = 14}{3 + 9 = 12}$
48 mm.	2168		$\frac{4 + 10 = 14}{4 + 10 = 14}$
46 mm.	2168		$\frac{6 + 9 = 15}{4 + 10 = 14}$

## MUGIL BRASILIENSIS.

*Material Studied.*

<i>Length.</i>	<i>KOH Cat. No.</i>	<i>Cat. No.</i>	<i>Caudal Fin Ray Count.</i>
190 mm.	2169	2128 U. S. Nat. Mus.	$\frac{3 + 10 = 13}{5 + 9 = 14}$
92 mm.	2170	66247 U. S. Nat. Mus.	
35 mm.	2171	86914 U. S. Nat. Mus.	$\frac{5 + 9 = 14}{4 + 9 = 13}$

## SPHYRAENIDAE.

1. *Sphyraena barracuda* (Walbaum).

(Text-figs. 12-14).

*Diagnostic Characters:*

4 hypurals, 2 dorsal and 2 ventral in two largest fishes.

6 hypurals, 3 dorsal and 3 ventral in 115 mm. fish.

Narrow posterior neural and haemal spines.

3 epurals with bases of posterior two back of neural of the last centrum.

Neural of last centrum blunt.

Haemal processes arising on the posterior half of the caudal centra.

Vertebral count: 12 caudal plus 12 trunk. Total 24.

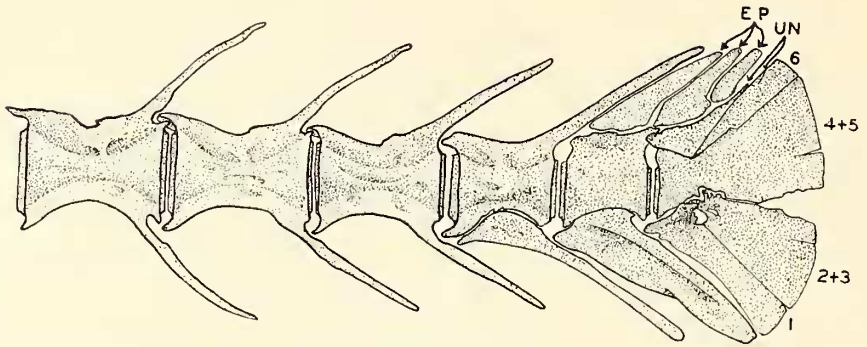
*Material Studied.*

<i>Length.</i>	<i>KOH Cat. No.</i>	<i>Text-fig. No.</i>	<i>Ossification.</i>
750 mm. (2 spec.).	2117	12	Complete.
503 mm.	598	13	Complete.
115 mm.	2089	14	Complete.

*Caudal Osteology.*

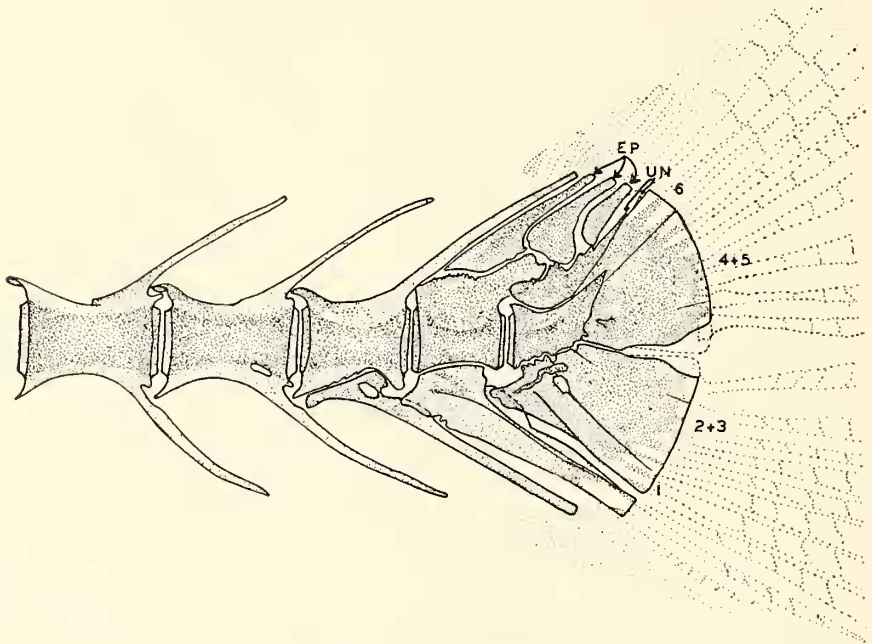
*Urostyle:* In the 750 mm. specimens, which are the largest in our collection, the urostyle appears completely consolidated with the bases of the 4th and 5th hypurals. On close examination the extremity of the urostyle can be seen as an inconspicuous tip about midway on the surface of the dorsalmost hypural. In the two smaller specimens the complete outline of the urostyle segment can be traced and in the 115 mm. fish it is more elongated, slender and separated from the surrounding bones.

*Uroneurals:* There are two pairs of uroneurals. Both are easily traced in the 115 mm. fish but the posterior pair is indistinct in the 503 mm. and



Text-figure 12.

*Sphyræna barracuda*. Tail of 750 mm. specimen showing fused hypurals, urostyle, and uroneurals. (x .8).



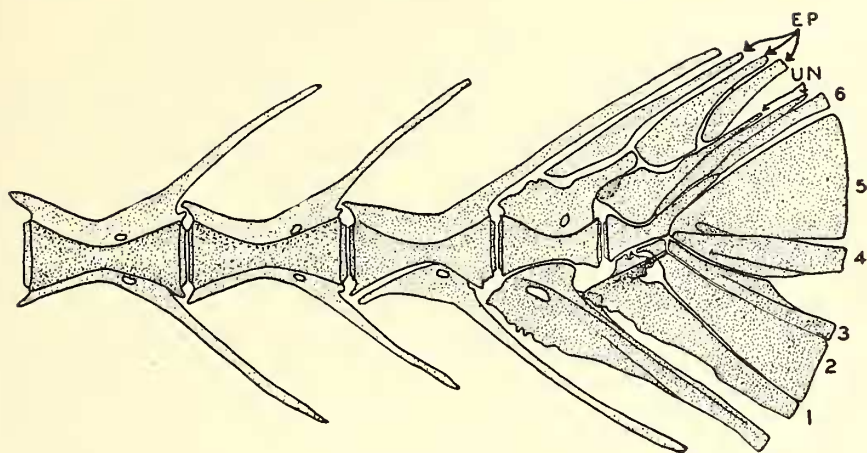
Text-figure 13.

*Sphyræna barracuda*. Tail of 503 mm. specimen showing only the trace of the urostyle and uroneurals. (x 1.38).

750 mm. specimens. Only the tip is evident near the distal end of the uppermost hypural with which it has become fused.

*Hypurals*: There are four hypurals, two below and two above the median line in the two largest fishes. But in each specimen a slight cleft is visible near the median line, in both of the large fan-shaped hypurals. In the 115 mm. specimens there are six complete hypurals. The clefts between the hypurals of the larger fishes are all that remain of the two additional





Text-figure 14.

*Sphyraena barracuda*. Tail of 115 mm. specimen showing form of six hypurals, the urostyle and two pairs of uroneurals. (x 6.5).

bones present in the younger stages. As in *Atherina* and *Mugil* the two median bones are large and fan-shaped.

**Epurals:** There are three epurals in all four specimens. The three epurals are club-shaped at the base and considerably narrower at their dorsal extremity. The anterior epural is the longest and the posterior one the smallest.

**Specialized Neural Processes:** The neural process of the terminal posterior centrum is blunt and heavy in form and the posterior neural end is never pointed.

*Caudal Fin Ray Count:*

750 mm.	$\frac{10 + 8}{10 + 9} = 18$	(2 spec.).
503 mm.	$\frac{7 + 10}{6 + 10} = 17$	(Text-fig. 13).
115 mm.	$\frac{9 + 8}{9 + 9} = 18$	

**Additional Characters Worthy of Note:** The bases of the posterior caudal haemal arches arise posterior to the center of their respective centra. This is a conspicuous difference from Mugilidae.

## 2. *Sphyraena borealis* De Kay.

*Diagnostic Characters:*

The caudal pattern of *Sphyraena borealis* is almost identical with that of *Sphyraena barracuda*. The caudal centra in *S. borealis* are slightly smaller in proportions and the dorsal and ventral raylets are more slender and do not extend as far forward as in *S. barracuda*. Also, the shape of the posterior end of the reduced last neural appears more rounded in all the *S. barracuda* but wider with a square-shaped end in *S. borealis*.



## SPHYRAENA BOREALIS.

## Material Studied.

Length.	KOH Cat. No.	Caudal Fin Ray Count.	Vertebral Count.
124 mm.	2087	$8 + 10 = 18$	12 + 12 = 24
		$7 + 9 = 16$	
114 mm.	2088	$7 + 10 = 17$	
		$5 + 9 = 14$	
109 mm.	2087	$7 + 11 = 18$	
		$8 + 8 = 16$	

## SPHYRAENA PICUDILLA.

## Material Studied.

260 mm.	515	$7 + 10 = 17$	12 + 12 = 24
		$7 + 10 = 17$	
230 mm.	514	$8 + 10 = 18$	
		$8 + 9 = 17$	
120 mm.	2090	$7 + 10 = 17$	
		$5 + 9 = 14$	

The *Sphyraena picudilla* material which has been studied and considered as one with *S. borealis* is for the sake of clarity listed above in order to show the similarity of two characters, at least, in the vertebral count and the caudal fin ray count.

## SUMMARY.

There is a marked similarity in external characters of the species of Atherinidae, Mugilidae, and Sphyraenidae, which are grouped together under the suborder Percosoces, but the study of their skeletons shows that these families are not as closely related as their external similarities indicate. For example, Atherinidae, considered the most primitive of living Percosoces, has a total vertebral count and a caudal count of almost twice the number found in Mugilidae and Sphyraenidae.

According to the caudal osteological pattern, *Atherina* seems to be less specialized and stands apart from the other Bermuda Percosoces. On the other hand Mugilidae and Sphyraenidae are drawn together.

*Hypurals*: In young specimens of the three families a 3d ventral hypural is present which is directly below the median line and similar in shape and position to the corresponding hypural in all the Bermuda Isospondyli. In the fully adult percosocids this bone becomes one with the 2nd hypural and in all species the pattern is similar in having two large median fan-shaped hypurals. It will be seen in the table that the species of Bermuda Percosoces, including the young, have fewer hypurals than the Bermuda Isospondyli.

*Urostyle*: In all species of Bermuda Percosoces the urostyle appears consolidated and there is no evidence of separate segments which are found in all of the Bermuda Isospondyli.

*Ray-scales*: There are no specialized ray-scales. These are prominent in the more generalized Bermuda Isospondyli: *Elops*, *Tarpon*, and *Albula*, and less obvious in the other Isospondyli.

The table sums up caudal counts and indicates similarities and differences in the species of Percosoces. This opportunity is taken to tabulate the counts of the Isospondyli of Part I for the purpose of comparison.

TABLE I.

Caudal counts, comparing families of Percosoces and the Isospondyli.

Percosoces	Hypurals.		Uroneurals.	Vertebral Count.	Caudal Fin Ray Count.
	Adult.	Young.			
Atherinidae	$4, \frac{2}{2}$	$5, \frac{2}{3}$	1	43 (22 + 21)	$\frac{19}{18}$
Mugilidae	$4, \frac{2}{2}$	$6, \frac{3}{3}$	1	24 (11 + 13)	$\frac{15}{16}$
Sphyraenidae	$4, \frac{2}{2}$	$6, \frac{3}{3}$	2	24 (12 + 12)	$\frac{18, 17}{19 \ 16}$
Isospondyli					
Elopidae	$9, \frac{5}{4}$		4	72 to 81 (49to57 + 24to26)	$\frac{18, 19}{16 \ 16}$
Megalopidae	$8, \frac{5}{3}$		3	57 (33 + 24)	$\frac{16, 16}{13 \ 14}$
Albulidae	$7, \frac{4}{3}$	$7, \frac{4}{3}$	2 adult. 4 young.	69 (42 + 27)	$\frac{18}{16}$
Dussumieriidae	$7, \frac{4}{3}$	$7, \frac{4}{3}$	3	43 (27 + 16)	$\frac{14}{12}$
Engraulidae	$7, \frac{4}{3}$		3	40 to 42 (20to21 + 20to21)	$\frac{18}{17}$
Clupeidae	$7, \frac{4}{3}$		3	37 to 40 (12to14 + 25to26)	$\frac{19}{16}$

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(For full bibliography refer to Part I).

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